INDOOR AIR QUALITY ASSESSMENT

Florence Sawyer School
100 Mechanic Street
Bolton, MA

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health
Indoor Air Quality Program
November 2018

Background

Building:	Florence Sawyer School (FSS)
Address:	100 Mechanic Street, Bolton, MA
Assessment Requested by:	Robert Frieswick, Interim Director of Facilities, Nashoba Regional School District
Reason for Request:	General indoor air quality (IAQ)
Date of Assessment:	October 18, 2018
Massachusetts Department of Public Health/Bureau of Environmental Health (MDPH/BEH) Staff Conducting Assessment:	Mike Feeney, Director, IAQ Program Jason Dustin, Environmental Analyst, IAQ Program
Building Description:	The FSS is a two-story brick building built in 1997
Building Population:	Approximately 800 total students and staff
Windows:	Windows are openable in some areas

IAQ Testing Results

Please refer to the IAQ Manual for methods, sampling procedures, and interpretation of results (MDPH, 2015). The following is a summary of indoor air testing results (Table 1).

- ***Carbon dioxide levels*** were above 800 parts per million (ppm) in the majority of occupied areas tested, indicating a lack of air exchange in these areas. Some areas were empty, which can reduce carbon dioxide levels.
- ***Temperature*** was within or close to the recommended range of 70°F to 78°F the day of the assessment.
- ***Relative humidity*** was below the recommended range of 40 to 60% in all areas the day of assessment as is typical during the heating season.
- ***Carbon monoxide*** levels were non-detectable (ND) in all areas tested.
- ***Fine particulate matter (PM2.5)*** concentrations measured were below the National Ambient Air Quality (NAAQS) limit of 35 $\mu g/m^3$ in all areas tested.

Ventilation

A heating, ventilating and air conditioning (HVAC) system has several functions. First it provides heating and, if equipped, cooling. Second, it is a source of fresh air. Finally, an HVAC system will dilute and remove normally occurring indoor environmental pollutants by not only introducing fresh air, but by filtering the airstream and ejecting stale air to the outdoors via exhaust ventilation. Even if an HVAC system is operating as designed, point sources of respiratory irritation may exist and cause symptoms in sensitive individuals.

Fresh air is provided by a combination of unit ventilators (univents) located in most individual classrooms (Picture 1) and roof top air handling units (AHUs) for common areas (e.g., library, gymnasium, etc.). The univents draw fresh air through a vent on the exterior wall (Picture 2). Air is mixed with return air from the room, filtered, heated (if needed) and delivered to the room (Figure 1). Some univents were obstructed by items placed on top or in front (Picture 3). Both the top and the vent at the bottom need to be kept clear of obstructions for the units to operate as designed. Air from the AHUs is filtered, heated or cooled as needed, and delivered to rooms via ducted supply vents (Picture 4).

FSS facilities personnel reported that there has been an ongoing problem with the computerized control system for the univents in classrooms. BEH staff noted that most univent fans were not operating during the assessment. Nashoba facilities staff reported that the controls impact the fan operation as well as the fresh air intake louvre control, which may help explain why most of the carbon dioxide readings were elevated in classes having full attendance. In addition, it was reported that occupants shut off the units. This prevents fresh air from being supplied to classrooms. To maximize air exchange, the MDPH recommends that both supply and exhaust ventilation operate *continuously* during periods of occupancy.

In order to have proper ventilation with a mechanical supply and exhaust system, these systems must be balanced to provide an adequate amount of fresh air while removing stale air from a room. It is recommended that existing ventilation systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994). It is unknown the last time these systems were balanced.

Microbial/Moisture Concerns

Water-damaged ceiling tiles were observed in a few areas (Picture 5, Table 1), which indicate leaks from the building envelope or plumbing system. In most cases, these leaks were reported to be historic (i.e., inactive). These tiles should be replaced after the leak is found and repaired.

It appeared most building materials were non-porous (e.g., concrete, tile). However, porous items (e.g., carpeting, books, boxes, etc.) stored on the floors or against exterior walls may be a source for microbial colonization if exposed to chronic moisture/condensation.

Classroom #136 was reported to have been vandalized in August. The vandals reportedly urinated and defecated on the carpeting in the classroom. Facilities personnel reported that when this damage was discovered the following day, carpeting was professionally cleaned/disinfected and dried. Since carpeting is considered a porous material, it is typically recommended to be discarded following such an incident involving bio effluents.

Some first floor classrooms were reported to have high humidity and associated odors during the warmer months. Carpeting is generally not recommended in areas prone to chronic moisture and/or condensation since it may allow microbial colonization of the carpeting or in the dust/debris within the carpeting itself. Non porous, nontoxic closed cell foam mats may be used in place of carpeting if floor activities are required.

Indoor plants were observed in a few areas (Picture 6). Some of these plants were placed on porous materials. Plants can be a source of pollen and mold, which can be respiratory irritants to some individuals. Plants should be properly maintained, equipped with non-porous drip pans, and should be located away from air diffusers to prevent the aerosolization of dirt, pollen and mold.

Some classroom sinks were noted to have a gap between the counter and the backsplash (Picture 7; Table 1). This condition may allow chronic moisture to porous building materials which may lead to microbial growth.

An inspection was conducted of the building exterior to identify other issues which could lead to water penetration. Overflow scuppers draining against the building exterior were noted (Picture 8). Some weep holes were found covered by soil/mulch (Picture 9). These weep holes should be kept clear to allow the free draining of water from the inner drainage plenum which has penetrated the brick. Also, vegetation was growing on or against the building, some of which was growing in front of fresh air intakes for univents (Picture 10). Lastly, the ground outside of room #136 appeared to be chronically moist. This side of the building does not receive sunlight so that it remains damp. In addition, the grading of the surface allows water to collect in a depression against the perimeter of the slab (Picture 11). Concrete can have a wicking effect to produce chronically moist conditions above the slab in this area.

Other IAQ Evaluations

Exposure to low levels of total volatile organic compounds (TVOCs) may produce eye, nose, throat, and/or respiratory irritation in some sensitive individuals. To determine if VOCs were present, BEH/IAQ staff examined rooms for products containing VOCs. BEH/IAQ staff noted hand sanitizers, cleaners/spray bottles, plug-in air fresheners, and dry erase materials in use within the building (Pictures 12 and 13). All of these products have the potential to be irritants to the eyes, nose, throat, and respiratory system of sensitive individuals. Due to the pervasive use of these products in schools throughout Massachusetts, the MDPH has produced a guideline called "Clean Air Is Odor-Free" which is included as Appendix A.

BEH staff noted that the univents have a small hole in the cabinet that may draw air from unconditioned areas and bypass the filter. Other pathways such as holes in ceiling tiles or around utilities were also discovered (Picture 14).

Some classrooms had personal fans. Some of these had dusty blades/housings (Table 1). Some supply diffusers and exhaust/return vents were also observed to be dusty. This dust can be reaerosolized when the equipment is activated.

In many areas, accumulated items including books, papers, toys and decorative items were observed on floors, windowsills, tabletops, counters, bookcases, and desks. Excess items on surfaces can make it more difficult for custodial staff to clean.

Many classrooms/areas had carpeting. Carpeting should be HEPA vacuumed daily and cleaned annually or semi-annually in soiled high traffic areas. Many classrooms had area rugs, which should also be cleaned regularly and discarded when too worn out or soiled to be cleaned.

Windows and window frames were uninsulated. Table 2 shows the temperature differences experienced between the window pane, frame, and inner walls throughout the classrooms. Note that there was a large impact on window temperature due to the windows being in sun or shade as well. This can have an effect on occupant comfort and perceived indoor air quality and be a source of excess energy use in the building.

Note that the Environmental Protection Agency (EPA) conducted a National School Radon Survey in which it discovered nearly one in five schools had "…at least one frequently occupied ground contact room with short-term radon levels above 4 [picocuries per liter] pCi/L" (US EPA 1993). The BEH/IAQ Program therefore recommends that every school be tested for radon, and that this testing be conducted during the heating season while school is in session in a manner consistent with USEPA radon testing guidelines. Radon measurement specialists and other information can be found at www.nrsb.org and http://aarst-nrpp.com/wp, with additional information at: http://www.mass.gov/eohhs/gov/departments/dph/programs/environmental-health/exposure-topics/iaq/radon.

Conclusions/Recommendations

Most of the above noted conditions are commonly found in schools throughout Massachusetts. The MDPH guideline "Indoor Air Quality in Schools" is included as Appendix B to explain in further detail how to remedy most commonly-found issues.

The following recommendations are made to assist in improving IAQ:

1. Make necessary repairs to univent controls to allow for proper function of fans and fresh air intake louvers.
2. Operate all supply and exhaust ventilation equipment continuously during occupied hours. Fresh air should be supplied even when the thermostat set points are met to avoid intermittent ventilation that may allow indoor pollutants to build up.
3. Remove items and furniture blocking univents both on top and along the front.
4. Educate occupants that the univents provide not only heat but fresh air and should never be shut off. Temperature/comfort complaints should be made through proper channels and followed up by facilities staff.
5. Consider installing anti-tamper plates on top of univents to prevent the units from being shut off by occupants.
6. Use openable windows to supplement fresh air during temperate weather. Ensure all windows are tightly closed at the end of the day or during the use of air conditioning.

7. Check exhaust vents (in classrooms and restrooms) for draw periodically and repair any non-operating motors/vents.
8. Remove vandalized carpeting in room #136. Consider using nontoxic, closed cell foam mats if floor activities are required.
9. Remove any carpeting exposed to chronic moisture/condensation (e.g., rooms on slab).
10. Seal any holes within univent cabinets to ensure that no air bypasses the filter. Seal other pathways in walls, floors, and ceilings (e.g., around utilities).
11. Consider adopting a balancing schedule of every 5 years for all mechanical ventilation systems, as recommended by ventilation industrial standards (SMACNA, 1994).
12. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Avoid the use of feather dusters. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).
13. Ensure roof and plumbing leaks are repaired and replace any remaining water-damaged ceiling tiles and building materials.
14. Inspect any stored supplies or porous items (e.g., books, papers, boxes, etc.) in areas prone to chronic moisture (e.g. slab floors). Discard any porous items noted to be water-damaged or have a musty odor. Store porous items on shelving and away from walls.
15. Regularly inspect roof drains to ensure they are free from debris and allow for proper drainage and prevent unnecessary use of overflow scuppers.
16. Consider removing the shed beneath the overflow scupper to avoid water splashing against building exterior.
17. Inspect all weep holes to ensure they are not covered with soil/mulch and allow for the free draining of water from inner drainage plenum.
18. Remove any vegetation growing on or within 5 feet of the building.
19. Consider re-grading the area outside of room #136 to allow storm water to drain away from the building exterior rather than pool adjacent to building slab.

20. Properly maintain plants, including drip pans, to prevent water damage to porous materials. Plants should also be located away from air diffusers to prevent the aerosolization of dirt, pollen, and mold.
21. Seal any gaps between the sink counter and backsplashes with appropriate caulking.
22. Eliminate the use of products and equipment that contain VOCs (e.g., air fresheners, scented cleaning wipes, scented hand sanitizer, etc.).
23. Continue to change filters for HVAC equipment 2-4 times a year. The MDPH recommends using pleated filters of Minimum Efficiency Reporting Value (MERV) of 8, which are adequate in filtering out pollen and mold spores (ASHRAE, 2012), if these can be used with current equipment.
24. Regularly clean/vacuum univent cabinets, supply/return/exhaust vents and fans to avoid aerosolizing accumulated particulate matter. To clean ceiling grills, remove and wash.
25. Consider reducing the amount of items stored in classrooms to make cleaning easier. Periodically move items to clean flat surfaces.
26. Univent fresh air intakes on the exterior of the building should be monitored for debris and cleaned periodically. Ensure any vegetation is removed that is growing in front of these air intakes.
27. HEPA vacuum carpeting daily and clean carpeting annually (or semi-annually in soiled high traffic areas). Clean area rugs similarly.
28. The school should be tested for radon by a certified radon measurement specialist during the heating season when school is in session. Radon measurement specialists and other information can be found at: www.nrsb.org, and http://aarst-nrpp.com/wp.
29. Consider adopting the US EPA (2000) document, "Tools for Schools", as an instrument for maintaining a good IAQ environment in the building available at: http://www.epa.gov/iaq/schools/index.html
30. Refer to resource manual and other related IAQ documents located on the MDPH's website for further building-wide evaluations and advice on maintaining public buildings. These documents are available at: http://mass.gov/dph/iaq.

Long Term Recommendation:

1. Consider upgrading window systems to high efficiency windows and properly insulated window frames to increase occupant comfort.

References

ASHRAE. 2012. American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) Standard 52.2-2012 -- Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size (ANSI Approved).

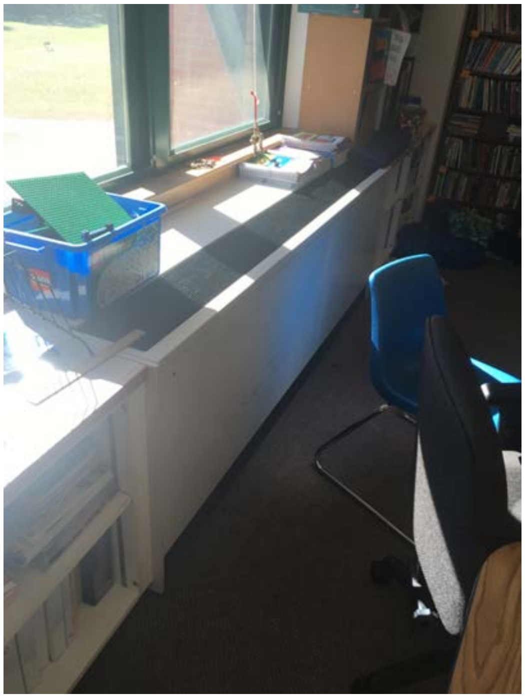
MDPH. 2015. Massachusetts Department of Public Health. "Indoor Air Quality Manual: Chapters I-III". Available at: http://www.mass.gov/eohhs/gov/departments/dph/programs/environmental-health/exposure-topics/iaq/iaq-manual/.

SMACNA. 1994. HVAC Systems Commissioning Manual. 1st ed. Sheet Metal and Air Conditioning Contractors' National Association, Inc., Chantilly, VA.

US EPA. 1993. Radon Measurement in Schools, Revised Edition. Office of Air and Radiation, Office of Radiation and Indoor Air, Indoor Environments Division (6609J). EPA 402-R-92-014. https://www.epa.gov/sites/production/files/2014-08/documents/radon_measurement_in_schools.pdf

US EPA. 2000. Tools for Schools. Office of Air and Radiation, Office of Radiation and Indoor Air, Indoor Environments Division (6609J). EPA 402-K-95-001, Second Edition. http://www.epa.gov/iaq/schools/index.html.

Picture 1



Univent in classroom

Picture 2

Exterior fresh air intake vent for classroom univent

Picture 3

Univent with items obstructing supply air flow

Picture 4

Ceiling-mounted supply air diffuser ducted from AHU

Picture 5

Water-damaged ceiling tile

Picture 6

Plants located in occupied space

Picture 7

Gap between sink and backsplash

Picture 8

Overflow roof scupper drains on shed below and against building

Picture 9

Weep hole (right arrow) and higher backfill covering other weep holes to the left

Picture 10

Vegetation against building and univent

Picture 11

Improper grading showing depression which allows water to collect against building

Picture 12

Plug-in air freshener

Picture 13

Fragrance refill package

Picture 14

Hole in ceiling tile showing abandoned utility pipe

Location: Florence Sawyer School **Indoor Air Results**

Address: 100 Mechanic Street Bolton, MA **Table 1** **Date: 10/18/2018**

Location	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 ($\mu g/m^3$)	Occupants in Room	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
Library	945	ND	74	27	13	14	Y	Y	Y	Carpet, served by roof top AHU
201	1108	ND	73	28	1	21	Y	Y	Y	
204	1240	ND	72	28	11	2	Y	Y	Y	WD CT
206	1238	ND	73	29	13	19	Y	Y on	Y	Floor tile, DEM
207	1223	ND	73	31	2	18	Y	Y	Y	
211	1479	ND	72	34	1	16	Y	Y	Y	Carpet
215	874	ND	72	26	0	0	Y	Y on	Y	
216	1458	ND	74	34	15	18	Y	Y on	Y	Carpet, CPs
218	1619	ND	73	36	15	12	Y	Y on	Y	Carpet, DEM
221	819	ND	73	24	0	0	Y	Y on	Y	AF, carpet
223	1591	ND	73	30	1	18	Y	Y on	Y	Books and items on vent

$\mu g/m^3$ = micrograms per cubic meter AF = air freshener CP = cleaning products DEM = dry erase materials PF = personal fan

ppm = parts per million AI = accumulated items CT = ceiling tile ND = non detect WD = water-damaged

Comfort Guidelines

Carbon Dioxide:	<800 = preferable	Temperature:	70 - 78 °F
	> 800 ppm = indicative of ventilation problems	Relative Humidity:	40 - 60%

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Location	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 ($\mu g/m^3$)	Occupants in Room	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
224	1955	ND	72	39	17	23	Y	Y off	Y	Carpet, PF, DEM
226	1612	ND	73	34	16	8	Y	Y	Y	WD CT
227		ND	73	36	3	16	Y	Y on	Y	Paper on vent, carpet
228	1970	ND	73	35	18	21	Y	Y off	Y	HS, carpet
230	1873	ND	72	37	19	20	Y	Y	Y	Carpet, PF
231	1970	ND	72	37	1	23	Y	Y on	Y	Carpet, bowed CT
232	1429	ND	73	27	15	4	Y	Y	Y	Carpet, PF
233	2019	ND	71	36	1	1	Y	Y on	Y	
235	1501	ND	72	34	4	1	Y	Y on	Y	Bowed CT
238	1362	ND	74	32	17	2	Y	Y	Y	Plants, DEM

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ppm = parts per million
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CP = cleaning products
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Location: Florence Sawyer School

Address: 100 Mechanic Street Bolton, MA

Indoor Air Results

Date: 10/18/2018

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								Supply	Exhaust	
239	1024	ND	73	34	0	2	Y			Carpet
242	1200	ND	72	31	18	2	Y	Y	Y	Carpet, DEM
243	1448	ND	68	38	1	23	Y	Y on	Y	Clutter, carpet
244	717	ND	71	26	11	0	Y	Y off	Y	Carpet
249	987	ND	75	29		3	Y	Y	Y	Lemongrass odor, plant, carpet
251 guidance	1005	ND	74	30	2	0	Y	N	N	
Gym	624	ND	69	18	2	0	N	Y	Y	
Cafeteria	891	ND	71	32	2	100+	Y	Y	Y	Bowed CT
Main Office	752	ND	70	26	2	1	Y	Y	Y	
Nurse	778	ND	70	27	2	0	N	Y	Y	

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								Supply	Exhaust	
Principal	809	ND	71	26	1	0		Y	N?	
Gym	709	ND	70	19	8	2	N	Y	Y	Floor polyurethane odor
Auditorium	650	ND	70	32	9	0	N	Y	Y	
Main office conference room	841	ND	70	29	8	4	N	Y	Y	Plant
129	857	ND	73	27	2	2	Y	Y	Y	AF
130	1102	ND	72	31	9	22	Y	Y off	Y on	Carpet, paint odor
136	953	ND	72	30	9	16	Y	Y on	Y	Carpet cleaner odor, gap in univent cabinet, reports of carpeting soiled/vandalized
140	1127	ND	72	33	10	4	Y	Y	Y	AI, carpet, hole in CT
141	1095	ND	72	31	2	2	N	Y	Y	Heavy perfume odor
142	1129	ND	71	31	9	0	Y	Y off	Y	Carpet, univent

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								Supply	Exhaust	
143	1070	ND	74	29	3	0	Y	Y	Y	Carpet
145	944	ND	74	24	0	0	Y	Y on	Y	Carpet
147	936	ND	73	27	1	0	Y	Y on	Y	Carpet
148	1055	ND	70	28	9	2	Y	Y	Y	Carpet
149	1261	ND	72	32	3	1	Y	Y	Y	Vent blocked by paper and bookcase, carpet
150	1408	ND	71	32	12	2	Y	Y	Y	
151	1166	ND	72	31	1	0	Y	N	N	Carpet
154	1250	ND	72	33	10	2	Y	Y	Y	Carpet
155	1413	ND	72	37	2	0	Y	Y on	Y	AF
156	1390	ND	70	31	10	2	Y	Y	Y	

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								Supply	Exhaust	
157	1954	ND	74	38	4	1	Y	Y on	Y	Carpet
158	542	ND	70	21	8	4	Y open	Y	Y	Tiles
160	1880	ND	72	34	11	17	Y	Y	Y	Art supplies, AI, air handling unit and univent
162	1428	ND	73	34	10	23	Y	Y	Y	Carpet, computers
165 lab	1145	ND	74	28	2	0	Y	Y on	Y	Wood grinder, 3 WD CT
166	978	ND	74	25	10	15	Y	Y on	Y	AI, area rug
171	1250	ND	74	31	11	0	N	N	N	
172	1269	ND	74	32	10	1	Y	N	N	Radiator, window
173	1067	ND	74	28	10	0	N	N	N	Band storage

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Address: 100 Mechanic Street Bolton, MA **Table 2** **Date: 10/18/2018**

Location	Window Glass Temperature (°F)	Window Frame Temperature (°F)	Interior Wall Temperature (°F)	Remarks
Lab	83	81	75	Sun, shade
154	85	83	73	Sun
155	86	85	76	Shade
136	68	56	75	Shade
140	68	61	73	Shade
Main Office	60	59	69	Shade
134	80	78	72	Sun
129	70	65	78	Shade
Band	97	85	76	Sun
160	61	59	71	Shade
162	64	70	75	
158	64	60	72	Shade
150	64	63	71	Shade
148	62	60	71	Shade

Location	Window Glass Temperature (°F)	Window Frame Temperature (°F)	Interior Wall Temperature (°F)	Remarks
149	67	66	75	Shade
143	60	63	74	Shade
145	72	73	76	Sun
Staff Lounge	62	69	74	
Conference	61	63	73	Shade
130	83	81	73	Sun
Café 1	68	62	75	Shade
Café 2	93	91	75	Sun
147	64	60	72	Shade
201	66	63	75	Shade
204	57	63	75	Shade
Library	72	82	74	Sun
216	67	67	75	Shade

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Location	Window Glass Temperature (°F)	Window Frame Temperature (°F)	Interior Wall Temperature (°F)	Remarks
218	66	66	76	Shade
221	65	66	77	Shade
223	61	65	72	Shade
227	69	81	77	Shade
228	64	62	73	Shade
230	75	81	76	
238	80	78	79	Shade
239	68	70	78	Shade
242	69	77	74	
Guidance	57	59	69	Shade
207	71	66	69	Shade
206	66	60	74	Shade
226	81	82	76	Sun

Location	Window Glass Temperature (°F)	Window Frame Temperature (°F)	Interior Wall Temperature (°F)	Remarks
226	69	64	76	Shade
224	68	66	73	
235	66	60	74	Shade
232	77	75	71	
233	66	60	73	
231	63	50	77	Sun
243	92	87	78	Shade
245	70	73	77	
249	67	64	75	